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Ryu et al.

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(54) **4-CYCLE ENGINE**

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(52) **U.S. Cl.** ..... **123/195 C**; 123/90.38; 123/195 R
(58) **Field of Search** ..... 123/90.31, 90.38, 123/195 R, 195 C

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

8-177441 7/1996 (JP) .

Primary Examiner—Noah P. Kamen
(74) *Attorney, Agent, or Firm*—Arent Fox Kintner Plotkin & Kahn

(57) **ABSTRACT**

A crankcase includes first and second case halves which are coupled to each other at a parting plane extending to obliquely intersect the axis of first and second bearing portions. A cylinder barrel and the first bearing portion are formed by molding integrally on the first case half to form an engine block. The second bearing portion is formed by molding integrally on the second case half and a side cover is coupled to an outer side surface of the engine block to define a valve operating chamber for accommodation of a valve operating mechanism. Thus, the distance between the first and second bearing portions for supporting opposite ends of a crankshaft can be reduced without being interfered by the valve operating mechanism, thereby enhancing the durability of the crankshaft. The valve operating mechanism can be assembled after coupling of the first and second case halves forming the crankcase, whereby the assemblability of the valve operating mechanism can be improved.

2 Claims, 6 Drawing Sheets

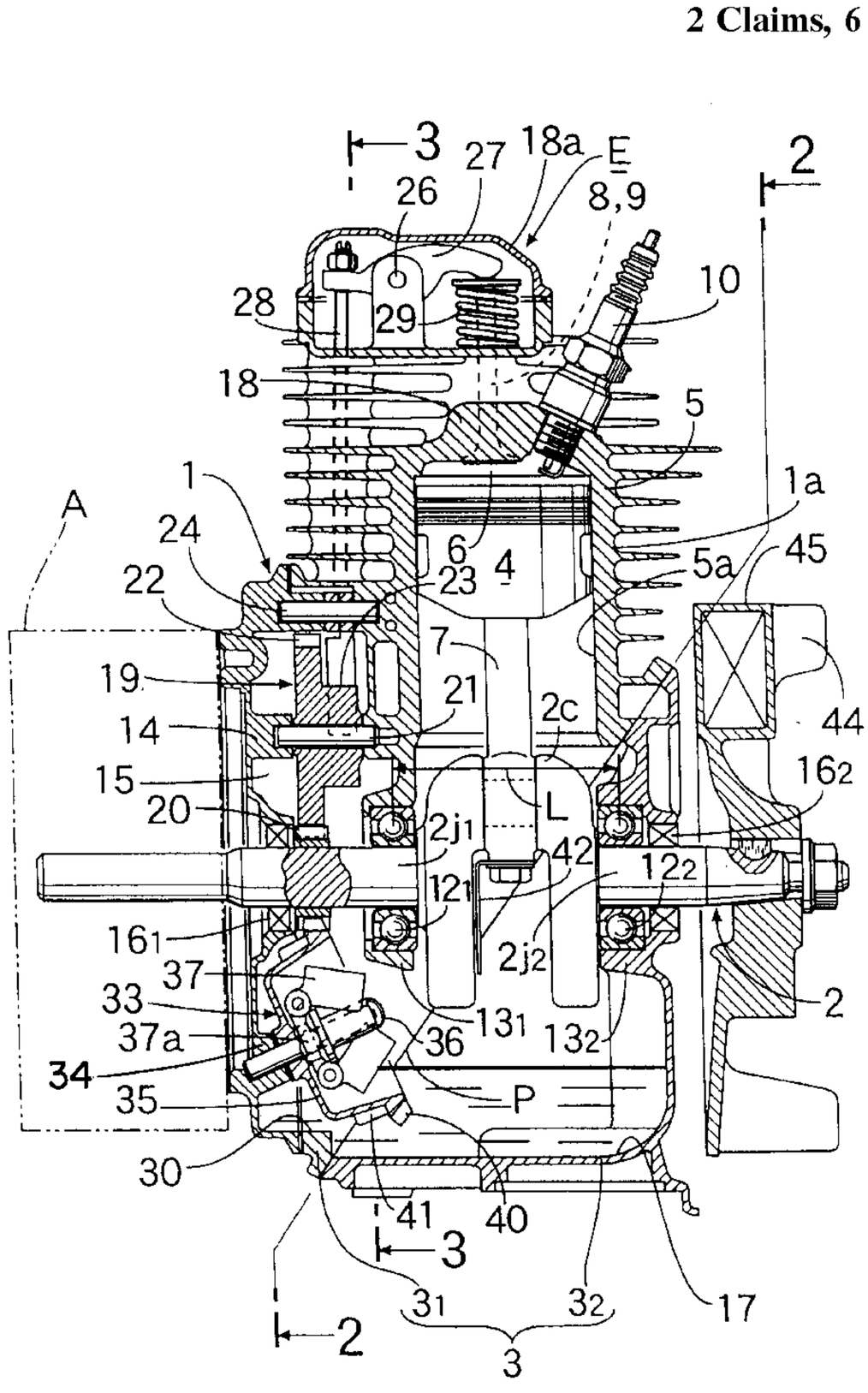

FIG.1

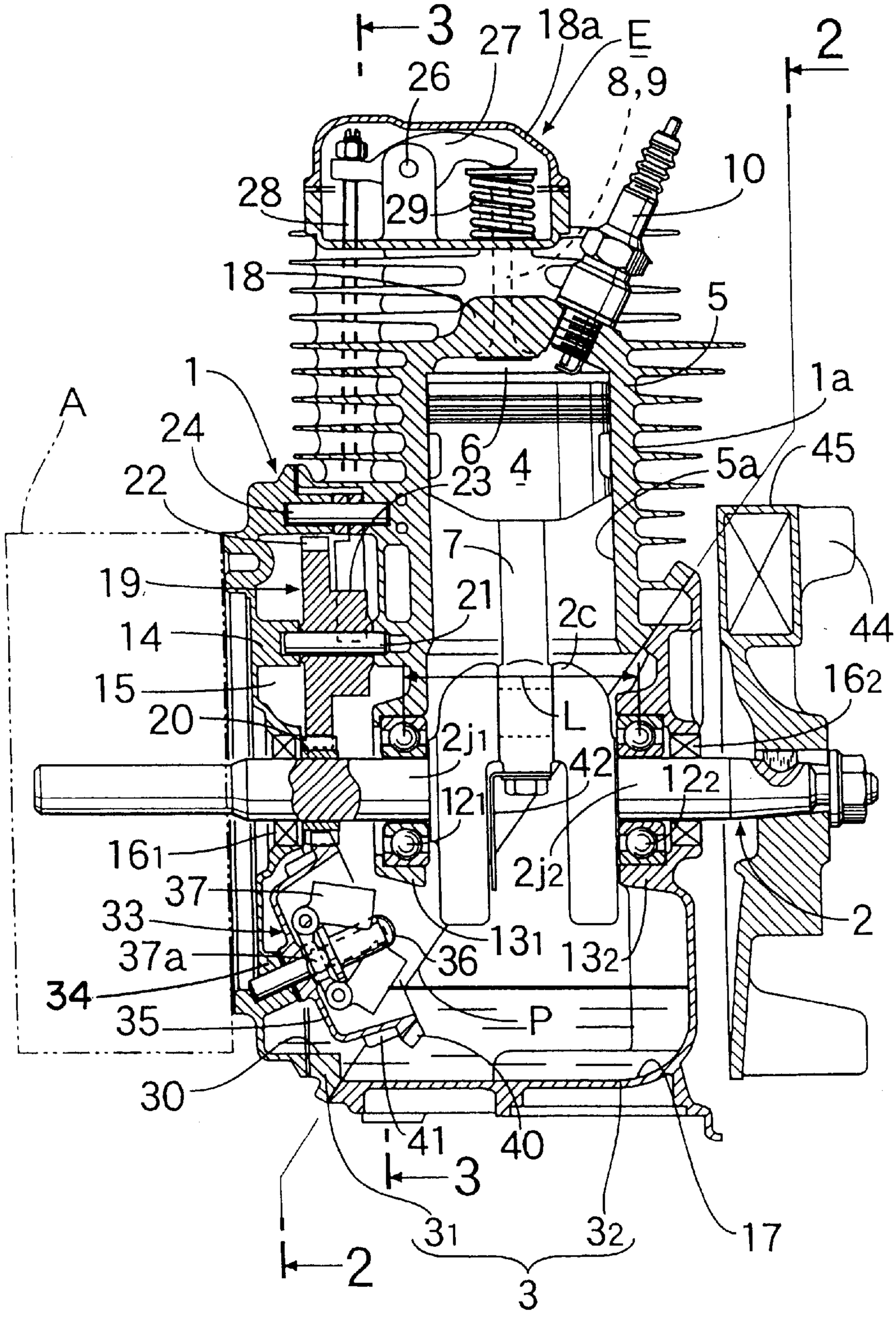
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FIG.2

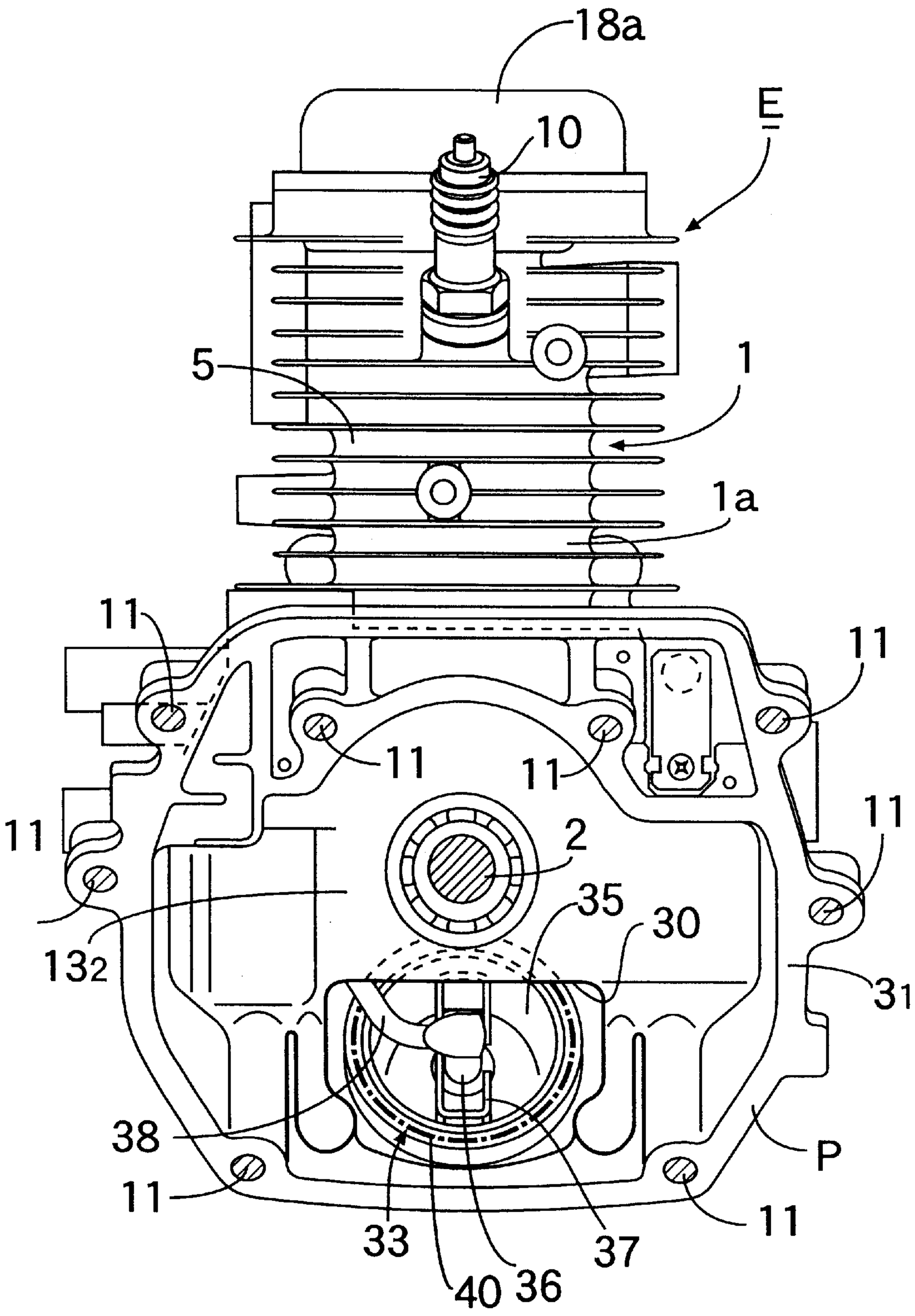

FIG.3

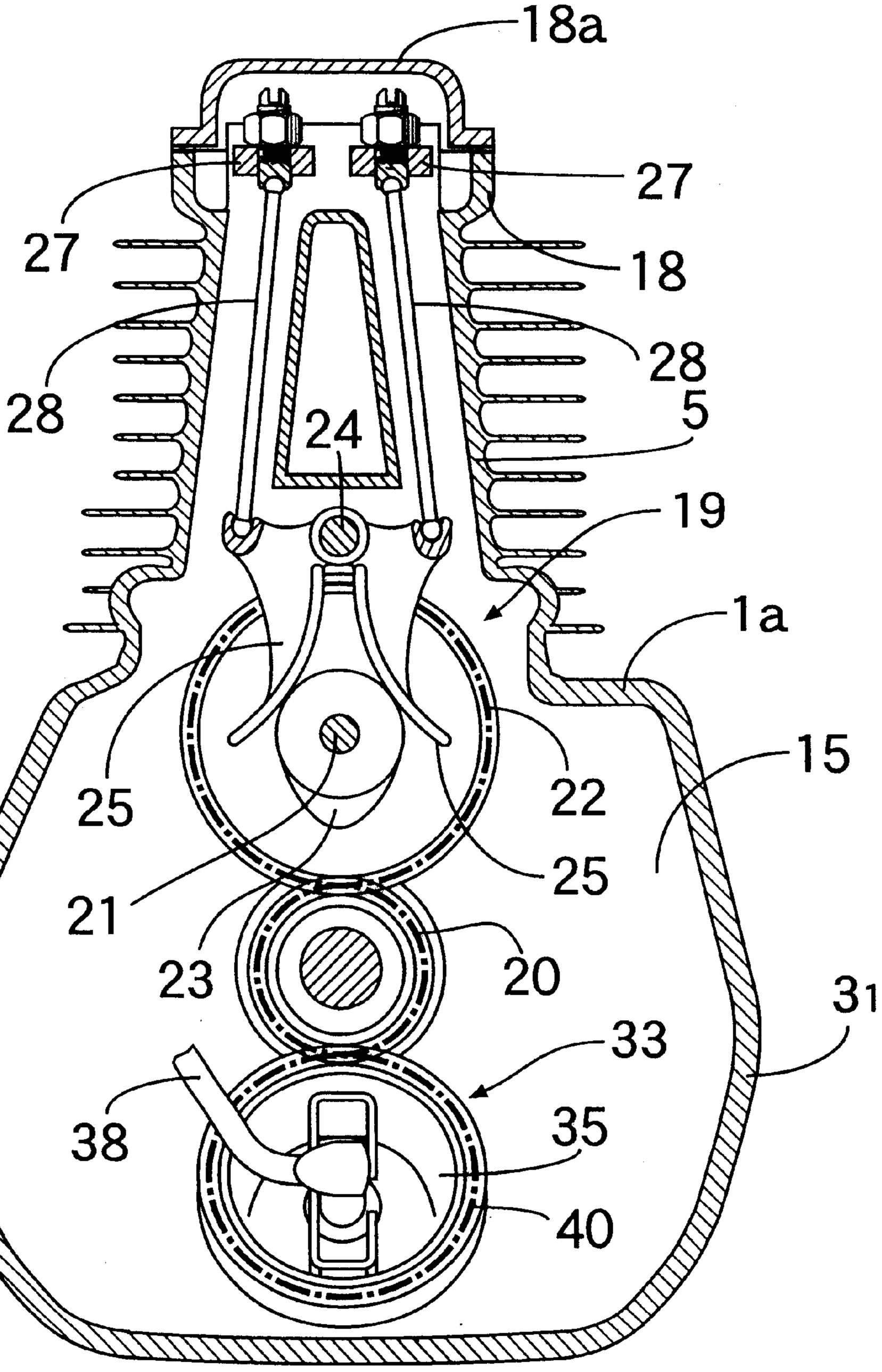

FIG.4

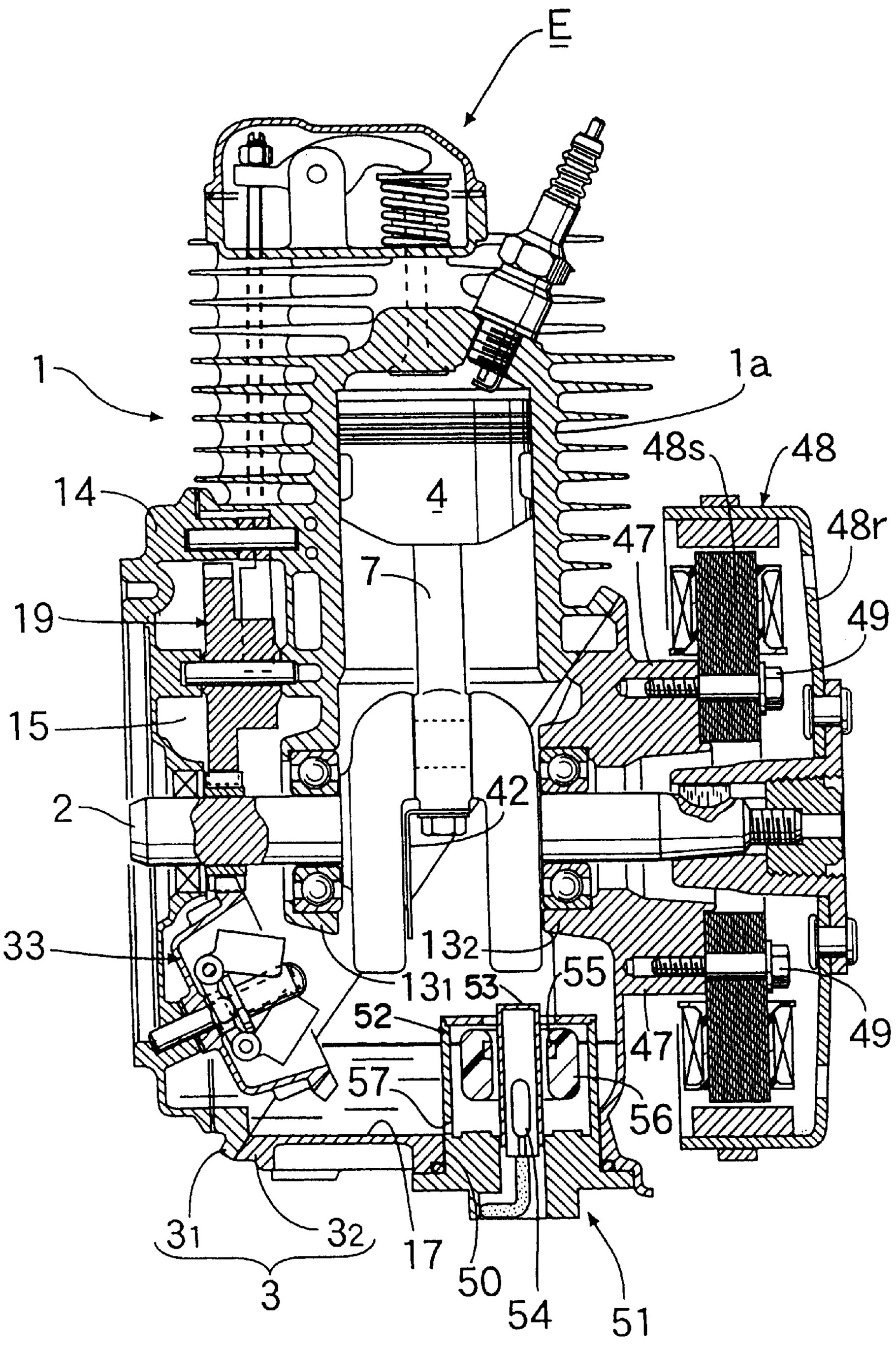
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FIG.5

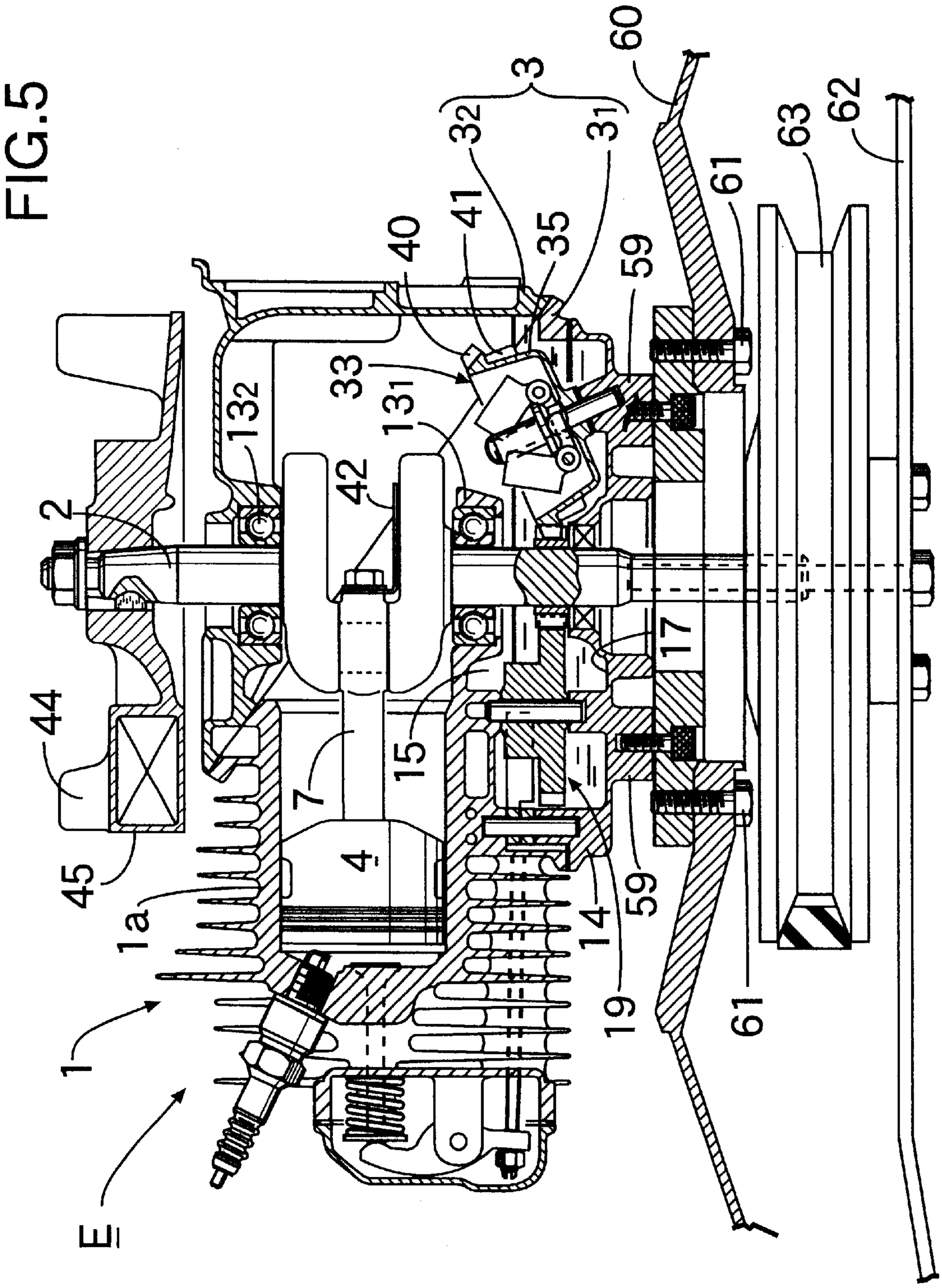
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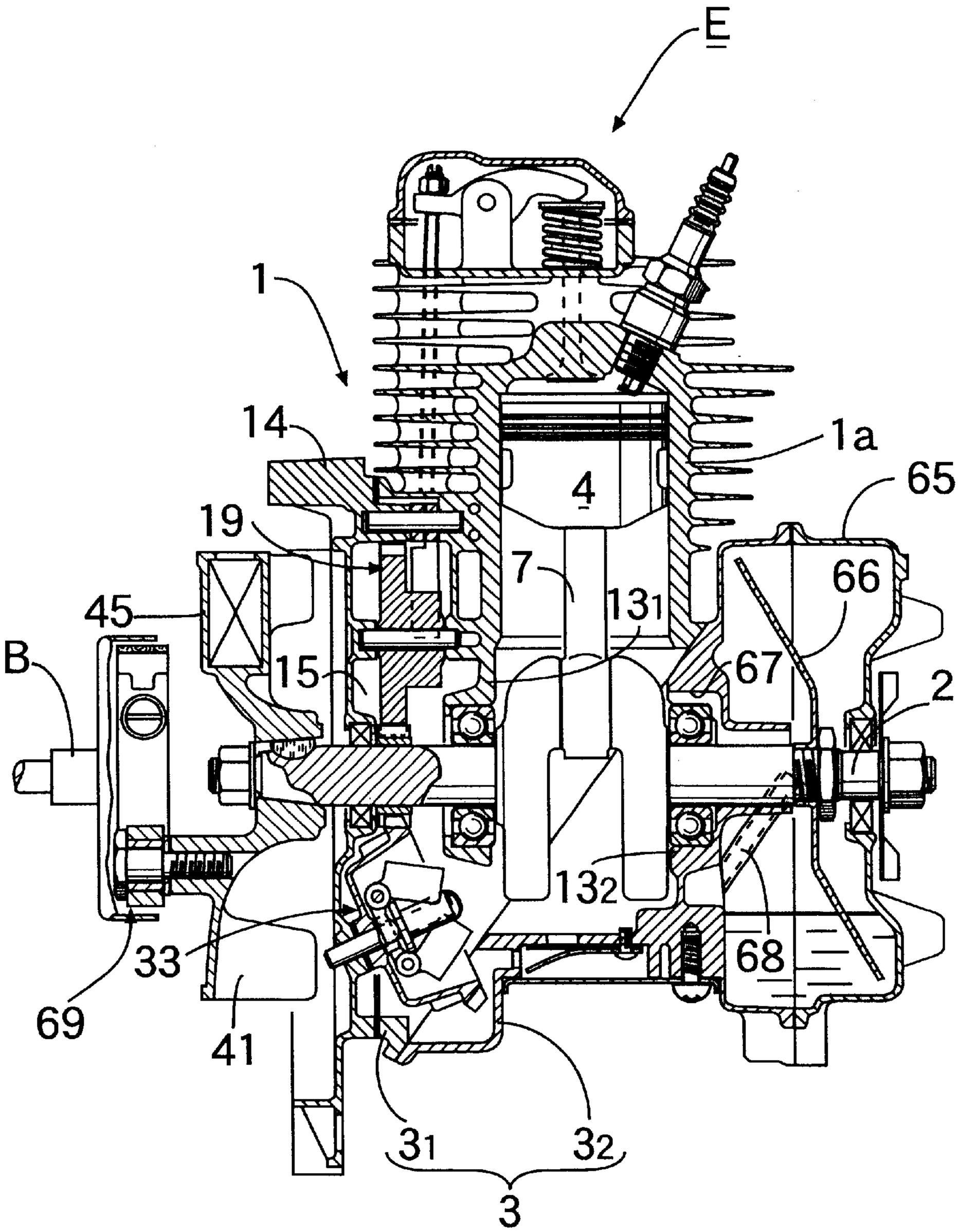
FIG.6



4-CYCLE ENGINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a 4-cycle engine, particularly, an improvement in a 4-cycle engine including an engine body which is comprised of a crankcase having first and second bearing portions for supporting opposite ends of a crankshaft, and a head-integral type cylinder barrel having a cylinder bore with a piston received therein.

2. Description of the Related Art

It is known, as disclosed, for example, in Japanese Patent Application Laid-open No. 8-177441, that in a 4-cycle engine of the mentioned type, the crankcase is comprised of first and second case halves which are coupled to each other at a parting plane extending to obliquely intersect the axis of the first and second bearing portions. The cylinder barrel and the first bearing portion are formed by being integrally molded on the first case half. The second bearing half is formed by being integrally molded on the second case half.

In this type of engine, it is effective to reduce the distance as much as possible between the first and second bearing portions for supporting the opposite ends of the crankshaft, in order to alleviate the bending moment generated on the crankshaft by a load applied from the piston to the crankshaft to enhance the durability of the crankshaft.

In the above conventional engine, however, a valve operating mechanism connected to the crankshaft is disposed adjacent the inside of the second case half. For this reason, when the distance between the first and second bearing portions is to be reduced, the valve operating mechanism is an obstacle. Namely, at least one of the bearing portions cannot be disposed adjacent a crank portion of the crankshaft, because it is hindered by the valve operating mechanism. When the engine is to be assembled, a portion of the valve operating mechanism is obliged to be temporarily assembled to the crankshaft before coupling the first and second case halves to each other. Hence, it cannot be said that assembling this type of engine is easy is good.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a 4-cycle engine of the above-described type, wherein the distance between the first and second bearing portions supporting the opposite ends of the crankshaft is reduced without being interfered with by the valve operating mechanism. The durability of the crankshaft is thereby enhanced. Moreover, the valve operating mechanism can be assembled to the crankshaft after coupling the first and second case halves to each other, which leads to easy assembling of the engine.

To achieve the above object, according to the present invention, there is provided a 4-cycle engine comprising an engine body which is comprised of a crankcase including first and second bearing portions for supporting opposite ends of a crankshaft. A head-integral type cylinder barrel has a cylinder bore in which a piston is received. The crankcase is comprised of first and second case halves which are coupled to each other at a parting plane extending to obliquely intersect an axis of the first and second bearing portions. The cylinder barrel and the first bearing portion are formed by being integrally molded on the first case half to form an engine block. The second bearing portion is formed by being integrally molded on the second case half. A side cover is coupled to an outer side surface of the engine block which is opposite from the parting plane, so as to define a valve operating chamber for accommodation of a valve operating mechanism between the side cover and the outer side surface.

With the arrangement of the present invention, the valve operating chamber is defined between the first case half and the side cover coupled to the outer side surface of the first case half. Therefore, the first and second bearing portions formed on the first and second case halves are disposed adjacent opposite ends of a crank portion of the crankshaft, respectively, without encountering any interference by the valve operating mechanism accommodated in the valve operating chamber and the distance between the first and second bearing portions is minimized. Thus, the bending moment applied from the piston to the crankshaft is reduced to enhance the durability the crankshaft.

Moreover, even after coupling of the first and second case halves, the assembling of the valve operating mechanism can easily be carried out in a state in which the side cover has been removed.

Further, it is possible to provide a 4-cycle engine at a low cost in various forms which can be applied for various uses, only by changing the shapes of the second case half and the side cover which are relatively small parts.

The above and other objects, features and advantages of the invention will become apparent from the following description of the preferred embodiment taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a vertical sectional front view of a 4-cycle engine formed in a standard type;

FIG. **2** is a sectional view taken along a line **2**—**2** in FIG. **1**;

FIG. **3** is a sectional view taken along a line **3**—**3** in FIG. **1**;

FIG. **4** is a vertical sectional front view of a 4-cycle engine formed for driving a generator;

FIG. **5** is a vertical sectional front view of a 4-cycle engine formed for mowing a lawn; and

FIG. **6** is a vertical sectional front view of a 4-cycle engine formed in a hand-held type.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention will now be described as being applied to a standard horizontal type 4-cycle engine with reference to FIGS. **1** to **3**.

In FIGS. **1** and **2**, reference character E designates a 4-cycle engine having an engine body **1**. The engine body **1** comprises a crankcase **3** which supports a crankshaft **2** horizontally, a cylinder barrel **5** having a cylinder bore **5***a* in which a piston **4** is slidably received, and a cylinder head **18** which defines a combustion chamber **6** between the cylinder head **18** and a top surface of the piston **4**. The crankshaft **2** has a crank portion **2***c* which is connected to the piston **4** through a connecting rod **7**. Intake and exhaust valves **8** and **9** and a spark plug **10** are mounted in the cylinder head **18**.

The crankcase **3** is comprised of a first case half $\mathbf{3}_1$ and a second case half $\mathbf{3}_2$ coupled to each other at a parting plane P which extends to obliquely intersect an axis of the crankshaft **2**. The three following parts are formed integrally together by casting to form an engine block **1***a*: the first case half $\mathbf{3}_1$, the cylinder barrel **5** and the cylinder head **18**. The

first and second case halves 3_1 and 3_2 are separatably coupled to each other by a plurality of bolts **11** (see FIG. **2**).

The crankshaft **2** includes first and second journal portions $2j_1$ and $2j_2$ formed thereon adjacent opposite sides of the crank portion **2***c*. First and second bearing portions 13_1 and 13_2 for supporting the first and second journal portions $2j_1$ and $2j_2$ through ball bearings 12_1 and 12_2 are formed by molding integrally molding them on the first and second case halves 3_1 and 3_2, respectively.

A side cover **14** is coupled by a plurality of bolts (not shown) to that outer side surface of the engine block **1***a* which is opposite from the parting plane P, thereby defining a valve operating chamber **15** between the side cover **14** and the outer side surface. Oil seals 16_1 and 16_2 are mounted respectively to the side cover **14** and the second case half 3_2 to come into close contact with an outer peripheral surface of the crankshaft **2**.

The first case half 3_1 is provided with an opening **30** which permits the valve operating chamber **15** and the inside of the crankcase **3** to communicate with each other below the first bearing portion 13_1. An oil reservoir **17** is defined to extend from the inside of the crankcase **3** to the valve operating chamber **15** for storing a lubricating oil in the bottom of the crankcase **3** and the valve operating chamber **15**.

An upper portion of the valve operating chamber **15** extends through a sidewall of the cylinder barrel **5** to above the cylinder head **18**, and an upper portion of the valve operating chamber **15** is closed by a head cover **18***a* which is coupled to an upper surface of the cylinder head **18**. A valve operating mechanism **19** is disposed in the valve operating chamber **15** for opening and closing the intake and exhaust valves **8** and **9** by rotating the crankshaft **2**.

As shown in FIGS. **1** and **3**, the valve operating mechanism **19** includes a drive timing gear **20** secured to the crankshaft **2** outside the first bearing portion 13_1. A driven timing gear **22** carried on an intermediate shaft **21** and driven at a reduction ratio of one half from the drive timing gear **20**. A cam **23** is connected to one end of the driven timing gear **22**. A pair of cam followers **25**, **25** are carried on a cam follower shaft **24** to be swung by the cam **23**. A pair of rocker arms **27**, **27** are carried on a rocker shaft **26** with one end thereof abutting against heads of the intake and exhaust valves **8** and **9**, respectively. A pair of push rods **28**, **28** connect the other ends of the rocker arms **27**, **27** to the cam followers **25**, **25**. Valve springs **29**, **29** bias the intake and exhaust valves **8** and **9** in closing directions. When the lift surface of the cam **23** pushes up the push rods **28**, **28** through the cam followers **25**, **25**, the intake valve **8** or the exhaust valve **9** is opened. When the base surface of the cam **23** faces the cam followers **25**, **25**, the intake valve **8** or the exhaust valve **9** is closed by a biasing force of the valve springs **29**, **29**.

The intermediate shaft **21** and the cam follower shaft **24** are supported at their opposite ends by the engine block **1***a* and the side cover **14**.

A regulating centrifugal governor **33** is mounted to the side cover **14** below the crankshaft **2** and driven by the drive timing gear **20**. The centrifugal governor **33** is comprised of a rotary board **35** supported on a support shaft **34** fixedly mounted on an inner wall of the side cover **14**. A cylindrical slider **36** is slidably fitted over the support shaft **34**. A plurality of pendulum-type centrifugal weights **37** swingably are carried on the rotary board **35** with the slider **36** interposed therebetween. Each of the centrifugal weights **37** includes an operating arm **37***a* which allows the slider **36** to slide in one direction, when the centrifugal weight **37** is swung in a radially outward direction by a centrifugal force. When the slider **36** slides in the one direction, a throttle valve (not shown) of a carburetor is operated in the closing direction through a link mechanism **38**, as is conventionally common, thereby controlling the engine speed to a preset value.

The support shaft **34** is fixedly mounted to the side cover **14** with an inclined attitude with its tip end directed toward the second bearing portion 13_2, whereby the rotary board **35** is maintained in such an inclined attitude that its rotating plane is closer to the axis of the cylinder bore **5***a* toward its lower portion. The rotary board **35** is integrally formed, on an outer periphery thereof, with a driven gear **40** meshed with the drive timing gear **20**, and a plurality of oil splashing blades **41** adjacent the driven gear **40**. The rotary board **35** is disposed so that lower portions of the driven gear **40** and the oil splashing blades **41** are immersed in an oil in the oil reservoir **17**.

As shown in FIG. **1**, an oil dipper **42** is secured to a lower end of the connecting rod **7** by a bolt **43** for splashing the oil in the oil reservoir **17** by the vertical movement and swinging movement of the connecting rod **7**.

A flywheel **45** having a cooling fan **44** integrally formed thereon is secured to one end of the crankshaft **2** which protrudes out of the second case half 3_2, and a working equipment A used in a horizontal attitude, e.g., a rotor of a water pump is connected to the other end of the crankshaft **2** which protrudes out of the side cover **14**.

To assemble the engine E, the ball bearings 12_1 and 12_2 are mounted on the first and second journals $2j_1$ and $2j_2$ of the crankshaft **2** and are fitted into the first and second bearing portions 13_1 and 13_2 of the first and second case halves 3_1 and 3_2, and the case halves 3_1 and 3_2 are coupled to each other by the bolts. Then, the valve operating mechanism **19** is assembled in the valve operating chamber **15** outside the first bearing portion 13_1. Finally, the side cover **14** and the head cover **18***a* are coupled to the engine block **1***a* by the bolts. In this manner, in a state in which the first and second case halves 3_1 and 3_2 have been coupled to each other, and the crankshaft **2** has been reliably supported, the valve operating mechanism **19** is assembled. Therefore, it is unnecessary to perform a temporary assembling as in the prior art, leading to a easy assembling of the valve operating mechanism.

If a load is applied from the piston **4** through the connecting rod **7** to the crank portion **2***c* of the crankshaft **2** due to expansion or compression stroke during operation of the engine E, the load is supported by the first and second bearing portions 13_1 and 13_2 of the first and second case halves 3_1 and 3_2. In response to this load, a bending moment is generated in the crankshaft **2**, particularly between the bearing portions 13_1 and 13_2. However, this bending moment is smaller, since the distance L between the bearing portions 13_1 and 13_2 is shorter. As described above, the valve operating mechanism **19** is disposed in the valve operating chamber **15** outside the first bearing portion 13_1, and the bearing portions 13_1 and 13_2 are disposed adjacent the opposite ends of the crankshaft **2***c* without being hindered by the valve operating mechanism **19**, so that the distance L between the bearing portions 13_1 and 13_2 is minimum. Therefore, the bending moment can be maintained to the minimum, which can contribute to an enhancement in durability of the crankshaft **2**.

The centrifugal governor **33** is driven by the crankshaft **2** during operation of the engine E. Therefore, the driven gear

40 and the splashing blades 41 of the rotary board 35 splash the oil in the oil reservoir 17 upwards while agitating the oil, whereby the valve operating mechanism 19 and the other portions can be lubricated by the splashed oil.

The second case half 3_2 and the side cover 14 are relatively small parts unlike the engine block 1*a* and hence, it is possible to provide at a low cost a 4-cycle engine E in various forms which can be applied for various uses which will be described below, only by changing the shapes and structures of the second case half 3_2 and the side cover 14.

FIG. 4 shows an example in which the second case half 3_2 is modified, whereby the engine E is formed for driving a generator. More specifically, a plurality of stator mounting bosses 47 are integrally provided on an outer side surface of the second case half 3_2 so as to protrude therefrom. A stator 48*s* of a generator 48 is secured to the bosses 47 by a bolt 49, and a rotor 48*r* is secured to the crankshaft 2 to surround the stator 48*s*. An alert mounting bore 50 is provided in a bottom wall of the second case half 3_2, and a housing 52 of an oil alert 51 is mounted in the alert mounting bore 50. Thus, the rotor 48*r* can be rotated by the operation of the engine E to generate an electric power.

A liquid-tight switch tube 53 is integrally formed at a central portion of a bottom wall of the housing 52, and a lead switch 54 is accommodated within the switch tube. An annular float 56 having a permanent magnet 55 embedded in an inner peripheral surface thereof is liftably fitted over an outer periphery of the switch tube 53. The housing 52 has a through-bore 57 provided therein with its inside communicating with the oil reservoir 17 in the crankcase 3, so that the oil can flow into and out of the oil reservoir 17. Therefore, when the oil level in the oil reservoir 17 is dropped until it is equal to or lower than a defined level, the float 56 on the oil is also lowered so that the magnet 55 is closer to the lead switch 54. Thus, an alarm which is not shown can be automatically operated by closing the switch 54 due to an action of the magnetic force of the magnet 55.

FIG. 5 shows an example in which the side cover 14 is modified, whereby the engine E is formed into a vertical type for driving a lawn mower. More specifically, a plurality of housing mounting bosses 59 are integrally formed on an outer side surface of the side cover 14. The engine E is mounted on a cutting edge housing 60 for a lawn mower with the side cover 14 directed downwards, and the cutting edge housing 60 is secured to the housing mounting bosses 59 by a bolt 61. A cutting edge 62 and a driven pulley 63 for driving a driven wheel through a belt (both not shown) are mounted to the crankshaft 2 within the cutting edge housing 60.

In this way, when the engine E is used as a vertical type, the oil reservoir 17 is defined in the valve operating chamber 15 with the side cover 14 directed downwards, so that a portion of the valve operating mechanism 19 is immersed in an oil. Thus, the valve operating mechanism 19 can be lubricated without hindrance.

On the other hand, the lower portion of the centrifugal governor 33 is placed in a state in which it is still immersed in the oil of the new oil reservoir 17. Therefore, the driven gear 40 and the splashing blades 41 of the rotary board 35 splash the oil upwards while agitating the oil to reflect the oil on the inner surface of the crankcase 3, whereby the crankshaft 2 and the piston 4 as well as the portions around them can reliably be lubricated.

In a case of such vertical-type engine E, the oil dipper 42 mounted to the connecting rod 7 cannot exhibit an intrinsic oil splashing function and hence, no problem occurs even if the oil dipper 42 is removed.

FIG. 6 shows an engine E which is formed into a hand-held type which drives a power trimmer, for example, by modifying the second case half 3_2. More specifically, an oil tank 65 for storing an oil in a given amount is formed in the second case half 3_2, and an oil slinger 66 for agitating the oil to produce an oil mist is secured to the crankshaft 2. The oil mist produced in the oil tank 65 is passed through a through-bore 67 in the second case half 3_2 into the crankcase 3, thereby lubricating the crankshaft 2 and the piston 4 as well as the portions around them. Further, the oil mist is passed into the valve operating chamber 15 to lubricate the valve operating mechanism 19. The oil liquefied after finishing of the lubrication is returned to the oil tank 65 through a return pipe 68 provided in the second case half 3_2. In this way, the various portions of the engine are lubricated by the oil mist and therefore, even if the engine E is used in any inclined state, the lubrication cannot be hindered.

The flywheel 45 secured to the crankshaft 2 is provided with a centrifugal clutch 69 which is operable to connect the flywheel 45 and a working machine B to each other, when the rotational speed of the crankshaft 2 is equal to or higher than a given value.

Although the embodiment of the present invention has been described in detail, it will be understood that the present invention is not limited to the above-described embodiment, and various modifications in design may be made without departing the spirit and scope of the invention defined in claims.

What is claimed is:

1. A 4-cycle engine comprising an engine body which is comprised of a crankcase including first and second bearing portions for supporting opposite ends of a crankshaft, and a head-integral type cylinder barrel having a cylinder bore in which a piston is received, wherein

said crankcase is comprised of first and second case halves which are coupled to each other at a parting plane extending to obliquely intersect an axis of said first and second bearing portions, said cylinder barrel and the first bearing portion being integrally molded on said first case half to form an engine block, said second bearing portion being integrally molded on said second case half, and a side cover is coupled to an outer side surface of said engine block on a side of the engine block opposite from said parting plane, so as to define a valve operating chamber for accommodation and support of a valve operating mechanism between said side cover and said outer side surface.

2. A 4-cycle engine according to claim 1, wherein said crankshaft has a crank portion located between said first and second bearing portions, and said crankshaft further has a gear formed thereon which is associated with said valve operating mechanism, one of said first and second bearing portions being disposed between said crank portion and said gear.

* * * * *